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(54) **SPUTTER TRAP HAVING MULTIMODAL PARTICLE SIZE DISTRIBUTION**

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See application file for complete search history.

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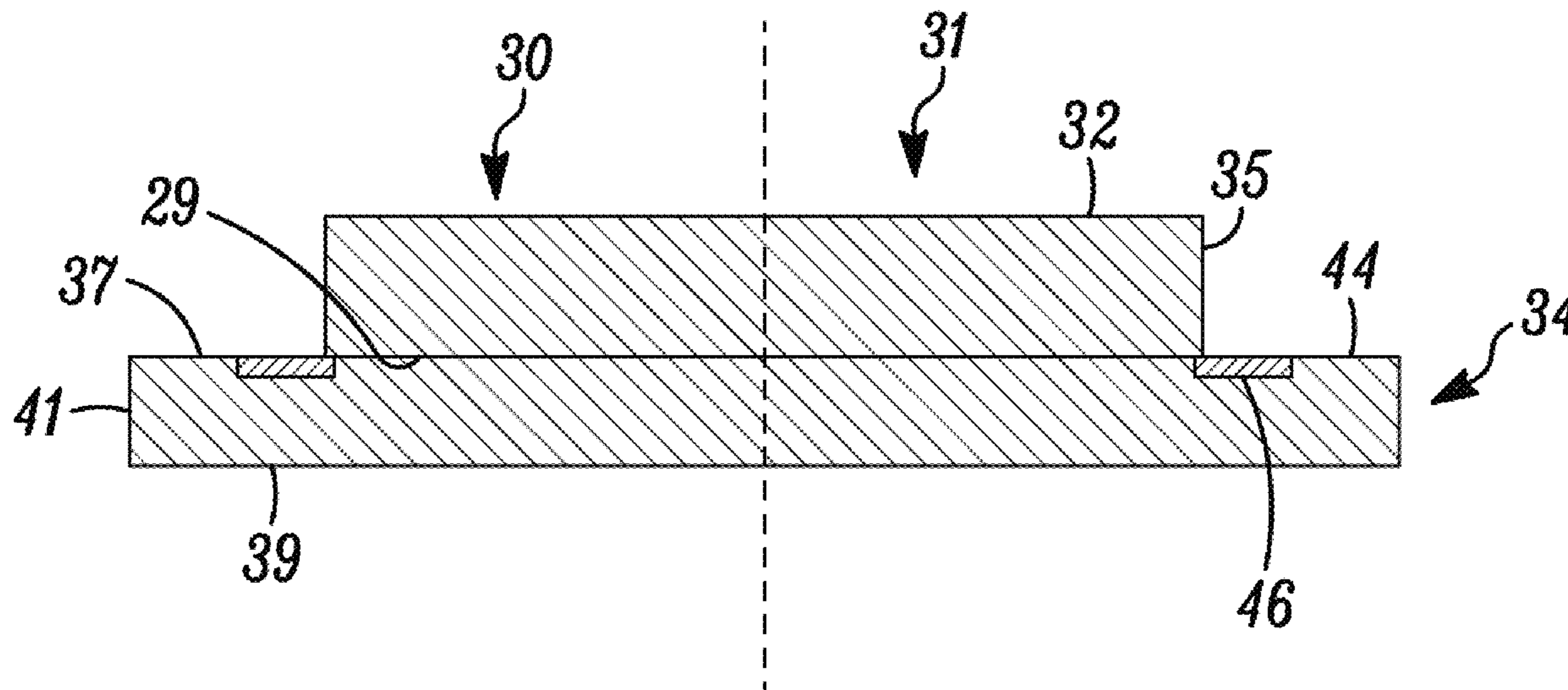
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(57) **ABSTRACT**
A sputter trap formed on at least a portion of a sputtering chamber component has a plurality of particles and a particle size distribution plot with at least two different distributions. A method of forming a sputter trap having a particle size distribution plot with at least two different distributions is also provided.

19 Claims, 5 Drawing Sheets



Related U.S. Application Data

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C23C 24/04 (2006.01)
C23C 14/02 (2006.01)
- (52) **U.S. Cl.**
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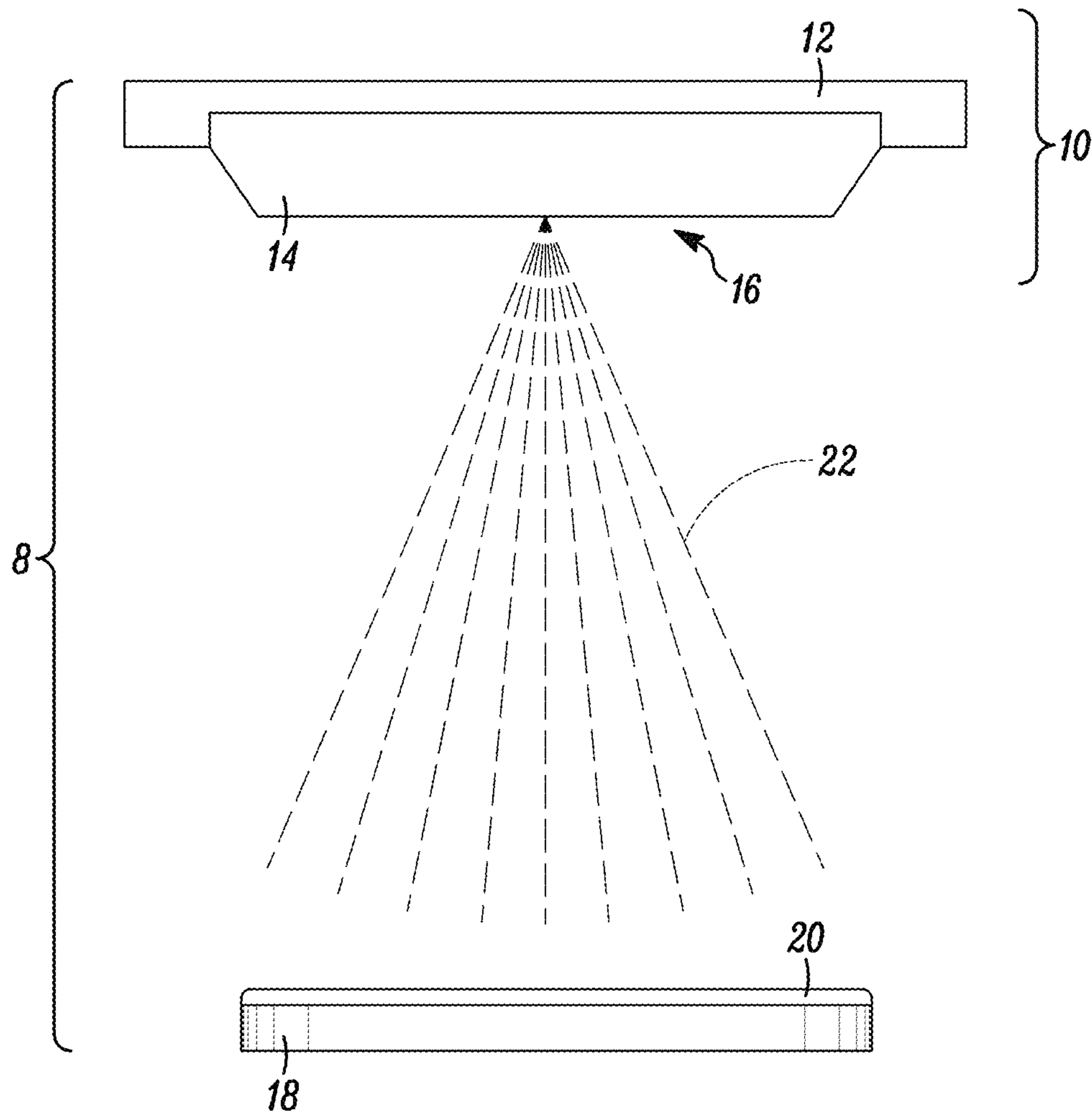


FIG. 1

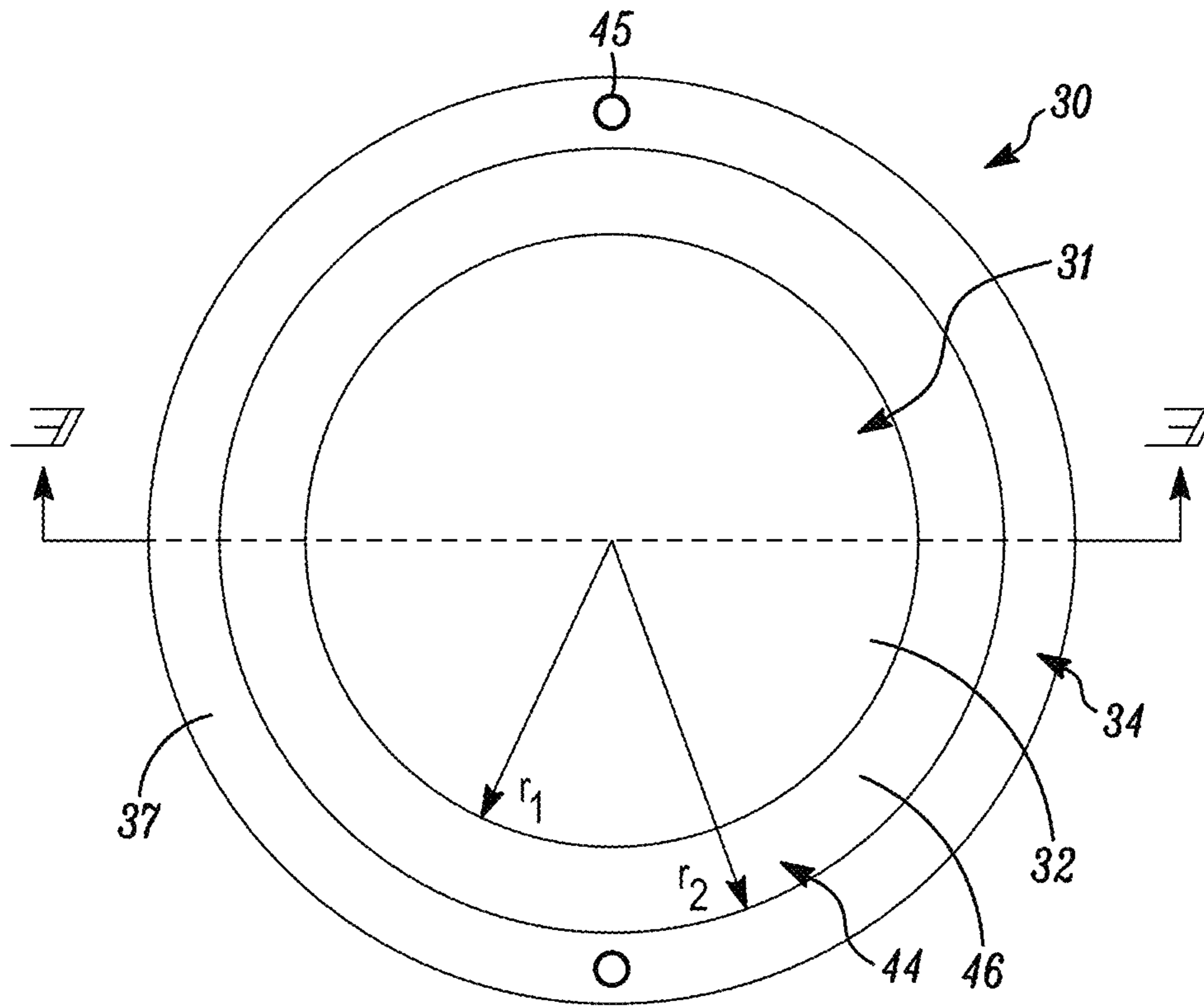


FIG. 2

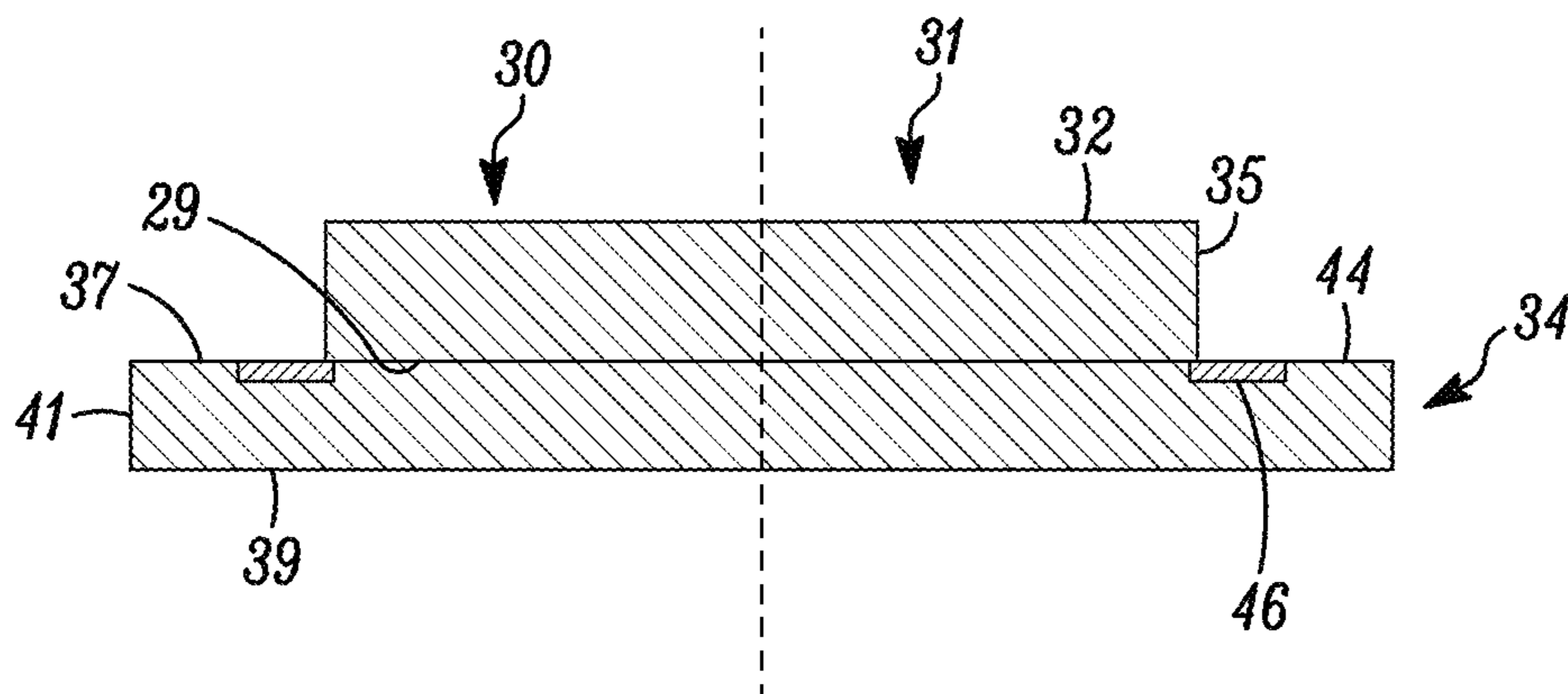


FIG. 3

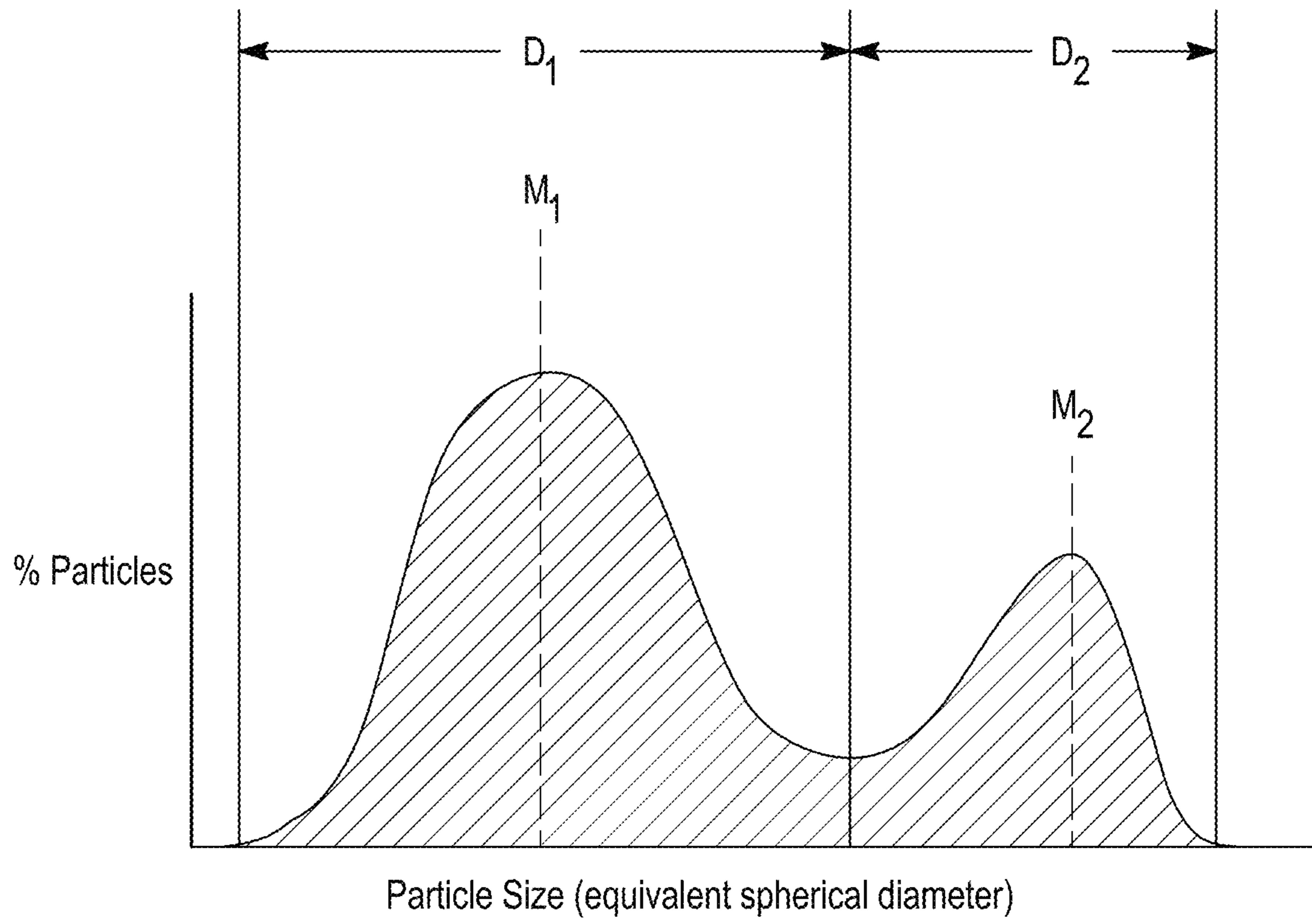


FIG. 4

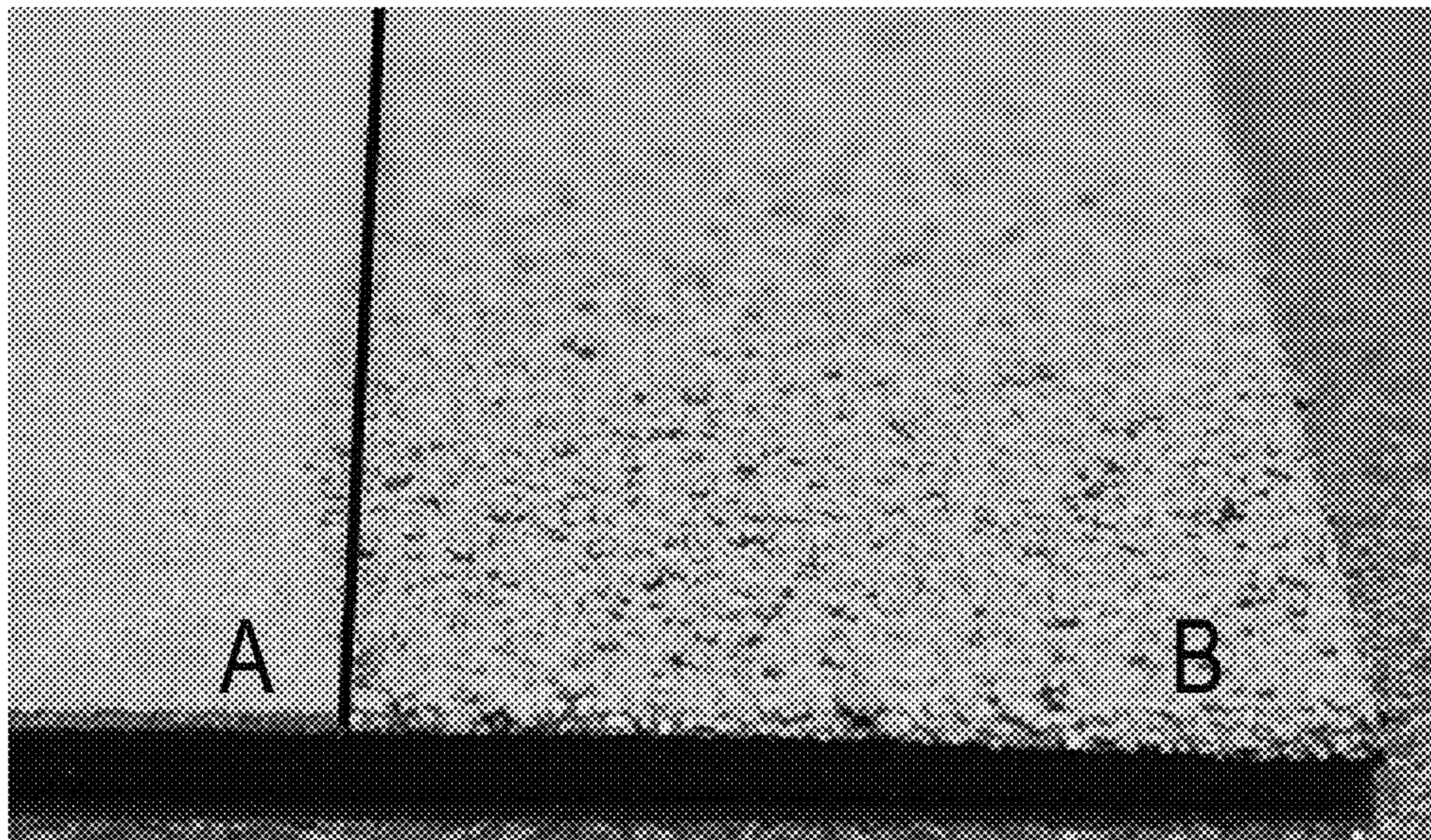


FIG. 5

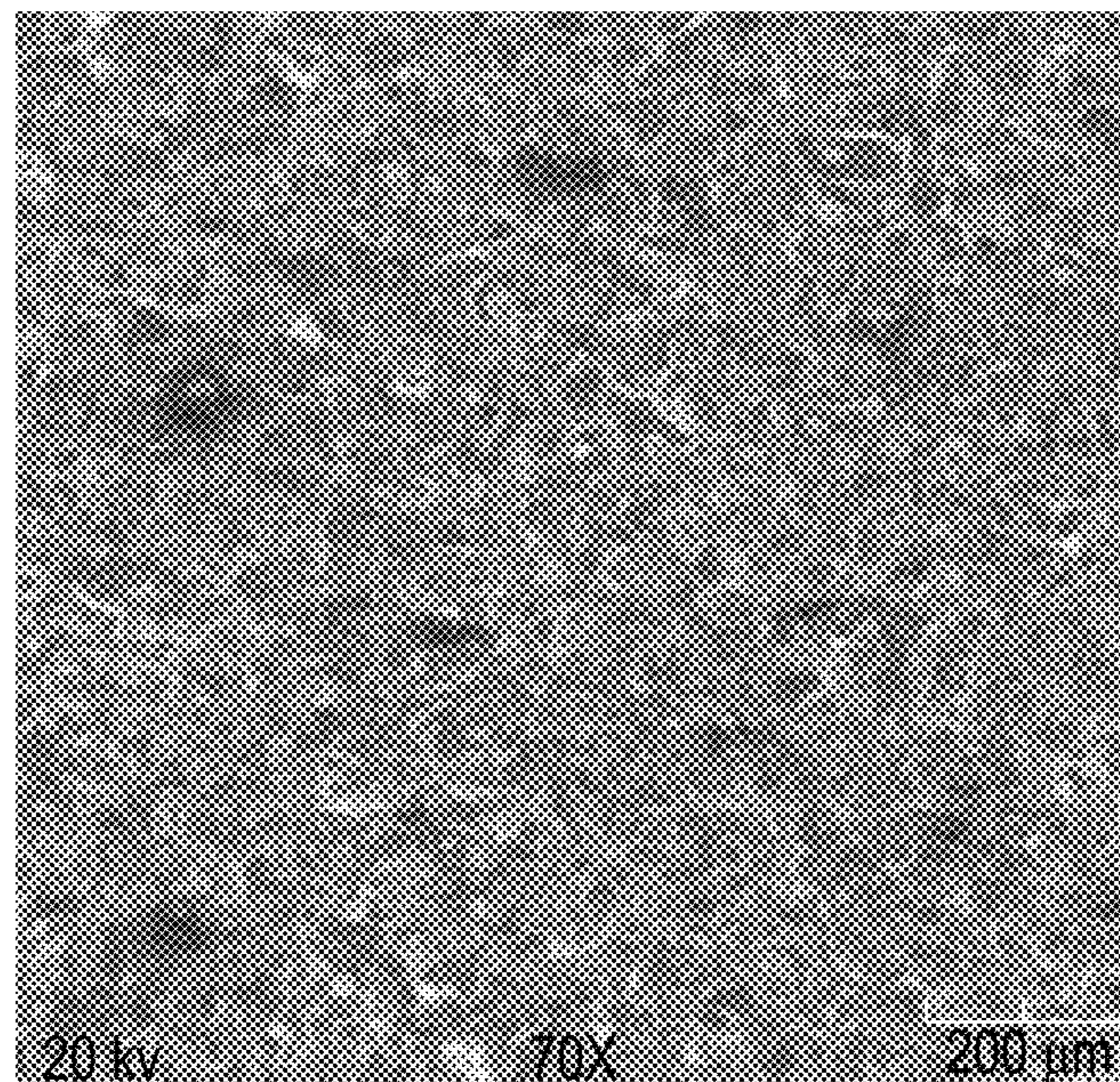


FIG. 6

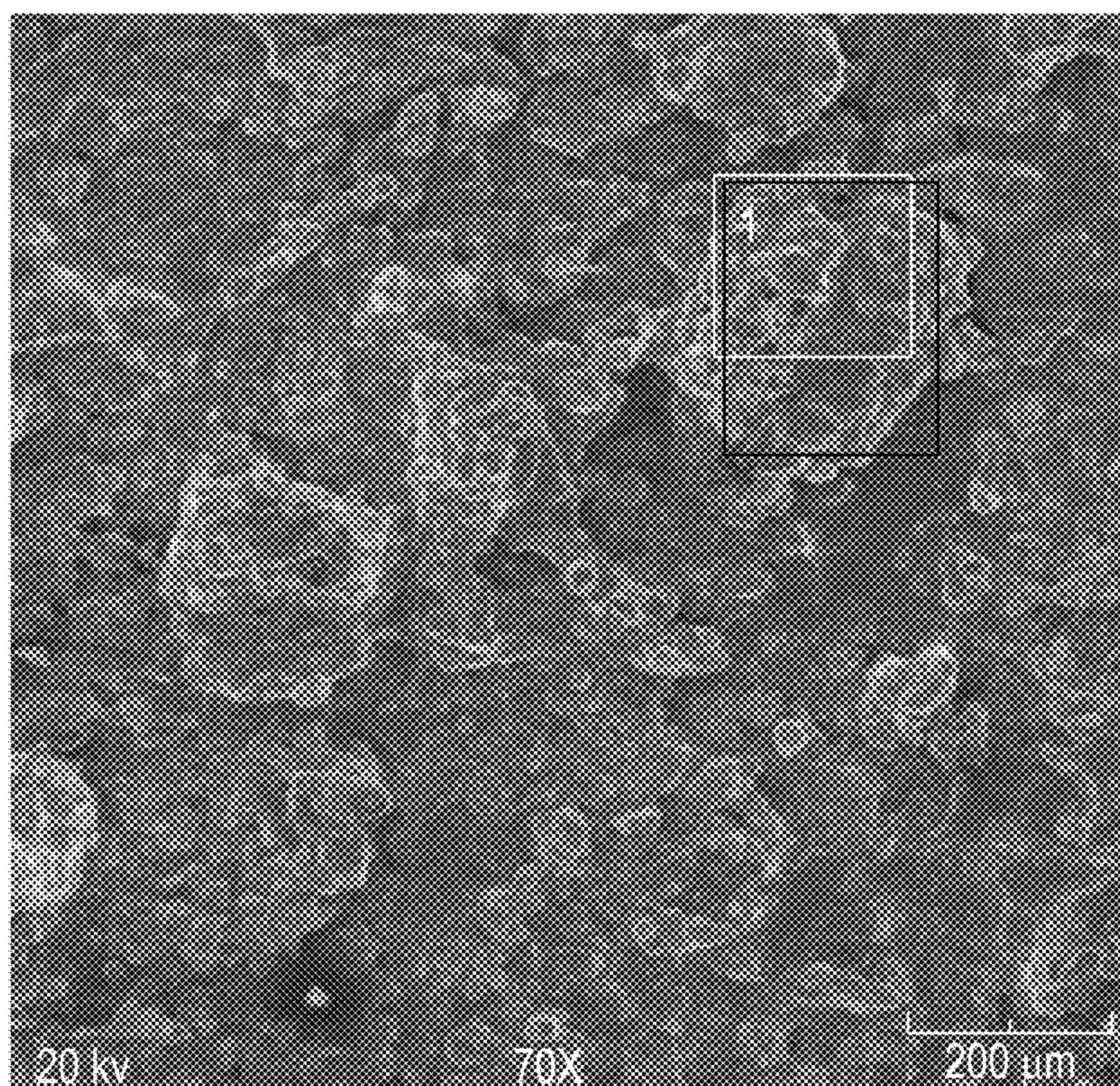


FIG. 7

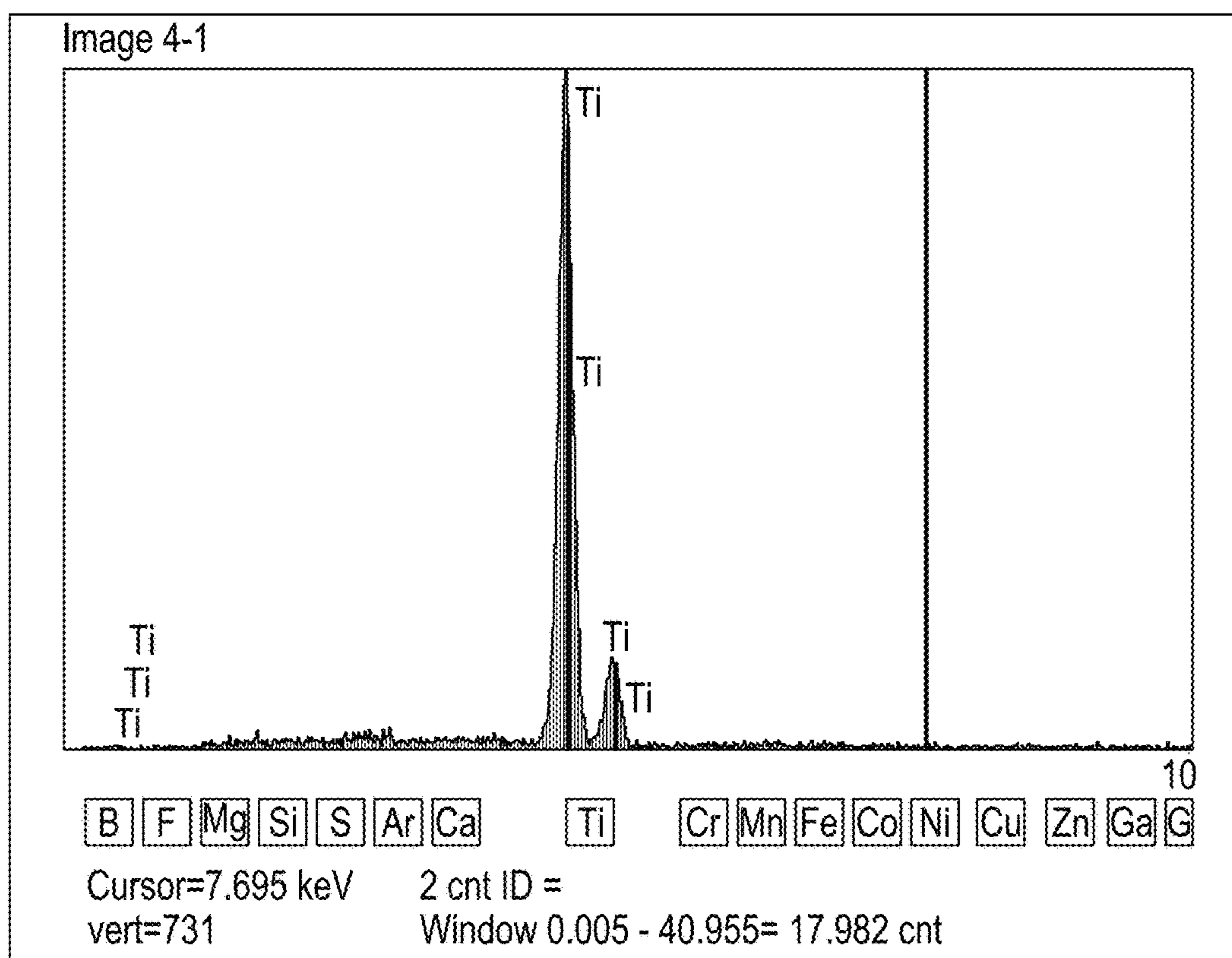


FIG. 8

SPUTTER TRAP HAVING MULTIMODAL PARTICLE SIZE DISTRIBUTION

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation application of U.S. patent application Ser. No. 15/824,802, filed Nov. 28, 2017, which claims priority to Provisional Application No. 62/434,673, filed Dec. 15, 2016, both of which are herein incorporated by reference in their entireties.

TECHNICAL FIELD

The instant disclosure relates to sputter or particle traps for use on sputtering chamber components and methods of making the same. More particularly, the instant disclosure relates to a sputter trap having a multimodal particle distribution.

BACKGROUND

Physical vapor deposition (“PVD”) methods can be used to form a film or layer of material on a substrate surface. PVD methods can be used in, for example, semiconductor fabrication processes to form metallized layers in the fabrication of integrated circuitry structures and devices. Sputter deposition is a PVD method in which a glow plasma discharge bombards a sputtering target which releases atoms that are subsequently deposited onto a substrate.

A diagrammatic view of a portion of an exemplary sputter deposition apparatus **8** is shown in FIG. **1**. In one configuration, a sputtering target assembly **10** comprises a backing plate **12** having a target **14** bonded thereto. A substrate **18** such as a semiconductive material wafer is within the sputter deposition apparatus **8** and provided to be spaced from the target **14**. As shown, the target **14** is disposed above the substrate **18** and is positioned such that a sputtering surface **16** faces substrate **18**.

In operation, sputtered material **22** is displaced from the surface **16** of target **14** and forms a thin film **20** on substrate **18**. In some embodiments, suitable substrates **18** include wafers used in semiconductor fabrication. For example, the target **14** is bombarded with energy until atoms from the surface **16** are released into the surrounding atmosphere and subsequently deposited on substrate **18**. In some embodiments, plasma sputtering is used to deposit a thin metal film onto chips or wafers for use in electronics.

Problems can occur in the deposition process if particles are formed, as these particles may fall into or onto a deposited film and disrupt desired properties of the thin film. A sputter or particle trap can be included on a sputtering target to capture particles formed during a deposition process. Additionally, there remains a risk that captured particles may flake off of the sputtering target and disrupt the thin film. For example, loosely held particles may flake from a sputter trap during cyclic thermal stress. Accordingly, it is desired to develop a sputter or particle trap that can be applied to a sputtering component, such as a sputtering target, which captures and retains particles formed during a deposition process. Capture and retention of such particles reduces the probability that a particles falls onto the deposited film during the deposition process.

SUMMARY

In some embodiments, a sputtering target assembly includes a front surface, a back surface opposite the front

surface, a sputtering surface on at least a portion of the front surface, a flange extending radially from the sputtering surface, and a sputter trap formed on at least a portion of a front surface of the flange. The sputtering trap includes a plurality of particles and has a particle size distribution plot with at least two different distributions.

In some embodiments, a method of forming a sputter trap on a sputtering target assembly includes adhering particles to at least a portion the sputtering target assembly by a cold spray technique or a thermal spray technique. The particle size distribution plot of the particles adhered has at least two different distributions.

In some embodiments, a sputter trap is formed on at least a portion of a sputtering chamber component. The sputter trap includes a plurality of particles having a particle size distribution plot with at least two different distributions.

While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a portion of a physical vapor deposition apparatus.

FIG. **2** is a schematic, top view of an exemplary sputtering target assembly.

FIG. **3** is a schematic, cross-sectional view along the line **3-3** of FIG. **2**.

FIG. **4** is an illustrative particle size distribution plot of a sputter trap having a bimodal particle size distribution.

FIG. **5** is an image of a witness sample multimodal sputter trap.

FIG. **6** is a scanning electron microscope micrograph of a sputter trap following bead blasting.

FIG. **7** is a scanning electron microscope micrograph of a multimodal sputter trap.

FIG. **8** is an energy dispersive X-ray spectroscopy (EDS) plot for pure titanium powders.

DETAILED DESCRIPTION

The instant disclosure relates to a sputter or particle trap for use on a PVD apparatus component and methods of making the same. In some embodiments, the PVD apparatus component is a sputtering target for use in a PVD sputtering chamber. However, one skilled in the art will recognize that the sputter trap may be formed on any component of a physical vapor deposition apparatus in which particles are a concern.

FIG. **2** is a top view of a sputtering target assembly **30** and FIG. **3** is a cross-sectional view of sputtering target assembly **30** taken along line **3-3** of FIG. **2**. Sputtering target assembly **30** includes a sputtering target **31** and a backing plate **34**. In some embodiments, sputtering target **31** and backing plate **34** having circular or substantially circular cross-sectional shape in the top view. In use, backing plate **34** is connected to the sputter deposition apparatus, for example, by bolts or clamps.

Sputtering target **31** has a front or sputtering surface **32**, a back surface **29** opposite the sputtering surface **32**, and a sidewall **35** extending between the sputtering surface **32** and the back surface about the circumference of sputtering target **31**. In some embodiments, the sputtering surface **32** may be

generally flat or planar. For example, the sputtering surface **32** may be parallel to a horizontal first plane. In other embodiments, the sputtering surface **32** may have one or more convex or concave portions or features. Additionally or alternatively, the back surface of the sputtering target **31** may be substantially planar. Alternatively, the back surface may have protrusions or indentations. For example, the back surface may receive or be received within a portion of backing plate **34**, a design which is known as an embedded backing plate.

Sputtering target **31** may be formed from any metal suitable for PVD deposition processes. For example, sputtering target **31** may include aluminum (Al), vanadium (V), niobium (Nb), copper (Cu), titanium (Ti), tantalum (Ta), tungsten (W), ruthenium (Ru), germanium (Ge), selenium (Se), zirconium (Zr), molybdenum (Mo), hafnium (Hf), and alloys thereof such as an Al alloy, a V alloy, a Nb alloy, a Cu alloy, a Ti alloy, a Ta alloy, a W alloy, a Ru alloy, a Ge alloy, a Se alloy, a Zr alloy, a Mo alloy, and a Hf alloy. Suitable alloys include but are not limited to copper-manganese (CuMn) alloys, aluminum-copper (AlCu) alloys, titanium-tungsten (TiW) alloys, tantalum-aluminum (TaAl) alloys, and ruthenium (Ru) alloys.

Backing plate **34** has front surface **37**, back surface **39** opposite front surface **37**, and sidewall **41** extending from front surface **37** to back surface **39** about the outer circumference of backing plate **34**. The back surface of sputtering target **31** is adjacent and bonded to front surface **37** of backing plate **34**. The radius of backing plate **34** is larger than that of sputtering target **31** such that at least a portion of the backing plate **34**, referred to as flange **44**, extends radially outward from the outer diameter or radial edge of the sputtering target **31**. In some embodiments, backing plate **34** may be formed from the same material as the sputtering target **31**. For example, backing plate **34** and sputtering target **31** may be part of an integral or monolithic sputtering target assembly **30**. In other embodiments, backing plate **34** and sputtering target **31** may be separate pieces which are bonded together. In such embodiments, the backing plate **34** may be formed of the same or different material than the sputtering target **31**.

Flange **44**, which extends radially outward from sputtering target **31**, may be substantially flat or planar. In some embodiments, the exposed portion of front surface **37** may be parallel or substantially parallel to the horizontal plane. In other embodiments, the exposed portion of front surface **37** may be in a plane at an angle to the first plane. Flange **44** can include one or more counter bore holes or/and through-holes **45** for connecting or bolting backing plate **34** to the sputter deposition source or apparatus.

Backing plate **34** may be formed from any suitable metal. For example, backing plate **34** may include aluminum (Al), vanadium (V), niobium (Nb), copper (Cu), titanium (Ti), tantalum (Ta), tungsten (W), ruthenium (Ru), germanium (Ge), selenium (Se), zirconium (Zr), molybdenum (Mo), hafnium (Hf), and alloys and combinations thereof. For example, alloys include an Al alloy, a V alloy, a Nb alloy, a Cu alloy, a Ti alloy, a Ta alloy, a W alloy, a Ru alloy, a Ge alloy, a Se alloy, a Zr alloy, a Mo alloy, and a Hf alloy. Suitable alloys include but are not limited to copper-manganese (CuMn) alloys, aluminum-copper (AlCu) alloys, titanium-tungsten (TiW) alloys, tantalum-aluminum (TaAl) alloys, and ruthenium (Ru) alloys. In some embodiments, backing plate **34** and sputtering target **31** may be formed of the same material. In other embodiments, backing plate **34** and sputtering target **31** may be formed of different materials.

Backing plate **34** also includes sputter trap **46** formed on the front surface **37** of flange **44**. In some embodiments, the sputter trap **46** can extend from where the sidewall of sputtering target **31** meets front surface **37** of backing plate **34**. For example, the sputter trap **46** can extend radially about the circumference of sputtering target **31**. In some embodiments, the back surface of target **31** can have an outer radius of $r1$ and sputter trap **46** can have an inner radius $r1$ and an outer radius $r2$. For example, sputter trap **46** can be formed immediately adjacent where target **31** joins to backing plate **34**. Additionally or alternatively, the sputter trap may be formed on the sidewall **35** of sputtering target **31**.

As discussed herein, particle formation during the sputtering process is a concern because such particles, if deposited on the substrate, will affect the uniformity of the film formed. Even if a particle is trapped or captured in a sputter trap, there is a potential that the particle may flake off during a sputtering deposition. Sputter trap **46** is configured to capture and prevent deposition particles formed during a sputtering deposition process onto the film formed. Additionally, sputter trap **46** is configured to retain the trapped particles. As described herein, sputter trap **46** can be formed by spraying and adhering particles onto backing plate **34** and/or along the circumference of sputtering target **31**. Suitable particles for forming sputter trap **46** include metals and metal alloys, ceramics, carbides, and metalloids. Suitable metal and metal alloy particles include titanium and titanium alloys.

For example, particles can be adhered to flange **44** to form sputter trap **46** by a thermal or cold spray process. Such process may form particles from a wire or powder source. For example, particles may be formed from a wire source by a twin wire arc spray process or may be formed from a powder using a plasma spray or cold spray process. The particles formed on the flange **44** have a particle size distribution. A particle distribution plot is formed by plotting particle size against the frequency (i.e., percent of particles). In a powder having a symmetric distribution, the particle distribution plot has a single distribution in the shape of a downward open parabola. The particle distribution plot has a single vertex or peak which is equal to the mean particle size. For a symmetric distribution, the mean, median and mode are equal. The width or breadth of the distribution can be described by the standard deviation or the coefficient of variation of the particles.

The particle size of spherical particles can be described by a diameter. Non-spherical particles are typically described by an equivalent spherical diameter. An equivalent spherical diameter is determined by measuring a physical characteristic, such as scattered light, and determining the size of sphere that would produce the measurement.

The particle size of the particles of sputter trap **46** can be determined using, for example, a scanning electron microscope (SEM), laser diffraction particle analyzer, or energy dispersive X-ray spectroscopy (EDS). Sputter trap **46** has a particle distribution plot having at least two distinct normal distributions, and each distribution has a mean. For example, the particle distribution plot for the particles of sputter trap **46** may resemble two partially overlapping parabolas. An illustrative plot is shown in FIG. 4, which has a first mean M_1 of a first distribution D_1 and a second mean M_2 of a second distribution D_2 . In some embodiments, the particle size distribution plot is from a representative sample area of the sputter trap **46**. For example, the particle size distribution plot may be created from four equally sized samples taken at four locations equally spaced about sputter trap **46**.

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The mean surface roughness (Ra) of sputter trap **46** may be at least 5 μm (200 microinches), at least 10 μm (400 microinches), at least 25 μm (1000 microinches), or greater than or equal to 38 μm (1500 microinches). In some embodiments, the Ra of sputter trap **46** may be about 15 μm (600 microinches) to about 50 μm (2000 microinches). The surface roughness may be determined using a surface roughness tester. Suitable surface roughness testers include the SurfTest SJ-410 series and the SurfTest SJ-201P series, which are both available from Mitutoyo of Aurora, Ill.

Sputter trap **46** may be formed by adhering particles, such as powder particles, to the textured surface. In some embodiments, a texture may be formed on sputter trap **46** before adhesion of the particles. For example, the textured surface may be formed by a saw, knurling device, computer numerically controlled (CNC) device, manual lathe or other suitable machining tool to form a random or repeating pattern. In some embodiments, a saw can be used to cut into a surface and leave the pattern. Alternatively or additionally, a knurling device can be used to press into the surface of the material and leave the desired pattern.

In some embodiments, the textured surface may have a height difference as measured from a maximum height to a minimum height from about 14 μm (550 microinches) to about 30 μm (1150 microinches), from about 19 μm (750 microinches) to about 29 μm (1125 microinches), or from about 23 μm (900 microinches) to about 28 μm (1100 microinches). For example, the textured surface may have height differential from about 13 μm (500 microinches) to about 18 μm (700 microinches), from about 13.5 μm (525 microinches) to about 17 μm (675 microinches), or from about 14 μm (550 microinches) to about 16.5 μm (650 microinches). In other embodiments, the textured surface may have a height differential from about 24 μm (950 microinches) to about 29 μm (1150 microinches), from about 25 μm (975 microinches) to about 28.5 μm (1125 microinches), or from about 25.5 μm (1000 microinches) to about 28 μm (1100 microinches).

The textured surface may additionally or alternatively be formed by bead blasting. When bead blasting is used, abrasive particles may be sprayed onto the surface, such as along the front surface of backing plate **34** and/or along the circumference of sputtering target **31**. Suitable abrasive particles for texturing sputter trap **46** include metals powders, ceramics, carbides, hardened alloys, glass bead, aluminum oxides, zirconia aluminum oxide, silicon carbide, steel grit, steel shot, and ceramic beads. In general, the particles of the bead blasting technique impact the surface creating a texture and are removed from the surface. The particles do not bond or adhere to the surface. Similarly, a knurling process presses a pattern into the surface to create a texture, and machining cuts a pattern (i.e., removes material) into the surface to create a texture. Knurling and machining are not intended to bond or adhere particles to the surface of sputter trap **46**.

Sputter trap **46** may also be subjected to grit blasting prior to adhering particles to the surface of sputter trap **46**. For example, sputter trap **46** having a textured surface may then be subjected grit blasting followed by adhesion of particles to the surface of sputter trap **46**. Suitable media for grit blasting include, for example, metals powders, ceramics, carbides, hardened alloys, glass bead, aluminum oxides, zirconia, aluminum oxide, silicon carbide, steel grit, steel shot, and ceramic beads. In some embodiments, the sputter trap **46** may be grit blasted to an Ra of about 2.5 μm (100 microinches) to about 15 μm (600 microinches). In some

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embodiments, the grit blasting process may increase adhesion of the particles applied in a subsequent process.

Sputter trap **46** is formed by adhering or coating particles, such as powder particles or particles from a wire, onto the surface. As discussed herein, the sputter trap **46** may be textured and/or subjected to grit blasting prior to adhering or coating particles to the surface of sputter trap **46**. In some embodiments, sputter trap **46** may be subjected to a thermal spray technique, such as plasma spray, high velocity oxygen fuel (HVOF) coating. Additional suitable methods for adhering particles to sputter trap **46** include a flame spray coating technique or twin wire arc spray coating technique using wire. In some embodiments, sputter trap **46** may be formed on the target assembly or backing plate by a cold spray technique in which the coating material, such as powder particles, are accelerated to high velocities by a supersonic compressed gas at temperature below the melting point of the coating material. The resulting coating is sputter trap **46** which is formed by the accumulation of numerous sprayed particles.

The powder particles used to form sputter trap **46** have a particle distribution plot having at least two peaks. For example, the powder mixture fed to the cold spray apparatus may be formed by mixing two powder compositions having different mesh sizes. Mesh size is the mesh number (a U.S. measurement standard) and its relationship to the size of the openings in the mesh and thus the size of the particles that can pass through these openings. For example, a first powder having a mesh size of 20 μm (635 mesh), 25 μm (500 mesh), 37 μm (400 mesh) or 44 μm (325 mesh) may be combined with a second powder having a mesh size of 210 μm (70 mesh), 74 μm (200 mesh), 88 μm (170 mesh) or 105 μm (140 mesh) to form a powder mixture which applied to the sputtering target assembly by a cold spray technique, in which the mesh size of the first powder is larger (corresponding to a smaller opening size) than the mesh size of the second powder (corresponding to a larger opening size) and the mesh sizes of the first and second powders are different. The powders may be combined in equal amounts by volume. Alternatively, the powder mixture may contain a greater amount by volume of the larger mesh size powder or a greater amount by volume of the smaller mesh size powder. For example, the powder mixture may be formed by mixing 45% by volume of the first powder and 55% by volume of the second powder. The mesh size and volume of each powder may be selected to achieve a desired surface roughness of the sputter trap. Suitable mesh sizes and volume content of a first powder and second powder for the powder mixture are provided in Table 1.

TABLE 1

	First Powder		Second Powder	
	Suitable mesh size	Suitable volume	Suitable mesh size	Suitable volume
Example 1	325 to 635	95% to 15%	70 to 270	5% to 85%
Example 2	325, 400, 500, 635	95% to 15%	70, 200, 170, 140, 120, 100, 80, 230, 270	5% to 85%

The powders may be of the same material or different materials. For example, the first and second powders may be titanium powders. It is also contemplated that the powder mixture is formed by combining three or more powders corresponding to different mesh sizes in equal or non-equal amounts by volume. In some embodiments, the powders

may be the same type of material as sputtering target **31**. For example, the powders and the sputtering target **31** may be nickel alloy materials.

Alternatively, the particles may be applied to the backing plate with a thermal spray coating techniques such as ultra high velocity (UHV), high velocity oxygen fuel (HVOF), plasma flame spray, twin wire arc, fusion bonded and wire metallizing. In a thermal spraying technique, the coating material is melted or heated and sprayed onto the surface. The coating material may be fed to the thermal spray device in a powder or wire form. The thermal spray device heats the coating material to a molten or semi-molten state and accelerates the material towards the flange in the form of micrometer-size particles. The resulting coating is sputter trap **46** which is formed by the accumulation of numerous sprayed particles, such as powder particles or melt materials.

In one embodiment, a sputter trap is formed by plasma spraying a powder mixture containing 44 μm (325 mesh) and 210 μm (70 mesh) titanium powder onto a flange of a sputtering target assembly. In some embodiments, the mixture may include about 50 vol % to about 45 vol % of 44 μm (325 mesh) titanium powder and about 50 vol % to about 55 vol % of the 210 μm (70 mesh) titanium powder.

When the coating material of the thermal spray coating process is a powder, the coating material may be formed by mixing two or more powder compositions having different mesh sizes as described herein with respect to cold spray techniques. When the coating material of the thermal spray coating process is a wire form, the thermal spray coating process is designed or controlled such that the material sprayed from the thermal spray device has particle size distribution having at least two peaks.

A sputter trap formed with one powder will have a particle distribution plot having a single peak (i.e., a mono-modal particle size distribution). The sputter trap disclosed herein is formed with a mixture of two or more powders having different mesh sizes and has a particle distribution plot having two or more different or independent distributions as illustrated by the particle distribution plot having two or more peaks (i.e., multi-modal particle size distribution). For example, a sputter trap formed with a mixture of two powders having different mesh sizes has a particle distribution plot having two separate distributions and having two peaks, and a sputter trap formed with a mixture of three powders having three different mesh sizes has a particle distribution plot having three distributions and having three peaks.

A sputter trap having a multi-modal particle size distribution as described herein may mitigate the potential flaking of prevalent planarized re-deposited film, which is a more stressed film as compared to a non-planarized re-deposited film per geometric effect or roughness effect, Ra of the sputter trap, along the sputter trap during a PVD sputtering process. The multi-modal particle size distribution forms a cluster type re-deposited film along the sputter trap during a PVD process and help reduce the fallen particles from the cyclic thermal stress. The multi-modal particle size distribution can also mitigate the potential flaking off of loosely held re-deposited particles during cyclic thermal stress. That is, the multi-modal particle size distribution of the sputter trap may result in particle reduction during the sputtering process.

The difference in mesh size of a multi-modal powder may also form a surface having an increased surface roughness as compared to a surface formed of only one of the particle sizes. For example, a sputter trap formed of a mixture of 210 μm (70 mesh) and 44 μm (325 mesh) powders may have a

surface roughness greater than a sputter trap formed of 210 μm (70 mesh) powder only or 44 μm (325 mesh) powder only.

FIG. **5** is an image of a witness sample sputter trap. The witness sample was subjected to grit blasting. Following grit blasting, Side B of the witness sample was subjected to a plasma spray process and bi-modal titanium powder particles were adhered to the surface of the sputter trap. A titanium powder was formed by mixing titanium powders having a first mesh size and a second mesh size and the titanium powder was plasma sprayed onto the sputter trap. Large particle sizes and small particle sizes are seen in FIG. **5**. In summary, Side A of the witness sample was subjected to grit blasting. Side B of the witness sample was subjected to the grit blasting following by plasma spray of a bimodal titanium powder.

FIG. **6** is a scanning electron microscope (SEM) micrograph of the sputter trap after bead blasting but before adhesion of particles. FIG. **7** is a SEM micrograph of a multimodal sputter trap after a plasma spray process in which a bi-modal titanium powder was adhered to the surface of the sputter trap. The bi-modal titanium powder was formed by mixing titanium powders having a first mesh size and a second mesh size. FIG. **8** is a plot depicting the elemental analysis of the high purity bi-modal titanium powder of FIG. **7** using an energy dispersive X-ray spectroscopy (EDS).

Various modifications and additions can be made to the exemplary embodiments discussed without departing from the scope of the present invention. For example, while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the above described features.

The following is claimed:

1. A sputtering target assembly comprising:

a front surface;

a back surface opposite the front surface;

a sputtering target on at least a portion of the front surface;

a flange extending radially from the sputtering target; and

a sputter trap formed on at least a portion of a front surface of the flange, the sputtering trap including a plurality of particles and having a particle size distribution plot with at least two distinct normal distributions, the plurality of particles comprising metals and metal alloys,

wherein the sputtering target assembly is a monolithic sputtering target assembly.

2. The sputtering target assembly of claim **1**, wherein the plurality of particles of the sputter trap include titanium particles, titanium alloy particles or combinations thereof.

3. The sputtering target assembly of claim **2**, wherein the plurality of particles of the sputter trap consist of titanium particles.

4. The sputtering target assembly of claim **1**, wherein the plurality of particles of the sputter trap include nickel alloy particles.

5. The sputtering target assembly of claim **1**, wherein the sputter trap has a surface roughness (Ra) of at least 38 μm .

6. The sputtering target assembly of claim **1**, wherein the particle size distribution plot has at least three distinct normal distributions.

7. A method of forming a sputter trap on a sputtering target assembly, the method comprising:

adhering particles to at least a portion the sputtering target assembly by a cold spray technique or a thermal spray technique, wherein the particle size distribution plot of

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the particles adhered has at least two distinct normal distributions, and the plurality of particles comprise metals and metal alloys,

wherein the sputtering target assembly is a monolithic sputtering target assembly.

8. The method of claim 7, and further comprising forming a textured surface on at least a portion of the sputtering target assembly with bead blasting, knurling or machining, and wherein the particles are adhered to at least a portion of the textured surface.

9. The method of claim 7, wherein the particles include titanium particles, titanium alloy particles or combinations thereof.

10. The method of claim 9, wherein the particles consist of titanium particles.

11. The method of claim 7, wherein the particles include nickel alloy particles.

12. The method of claim 7, wherein the method further comprises:

combining a first powder having a first mesh size and a second powder having a second mesh size to form a powder mixture, wherein the first mesh size and the second mesh size are different and wherein the step of adhering the particles to at least a portion of the sputtering target assembly includes providing the powder mixture to an apparatus for the cold spray or thermal spray technique.

13. The method of claim 12, wherein the first mesh size is from 44 (325 mesh) to 20 μm (635 mesh) and the second mesh is from 210 μm (70 mesh) to 53 μm (270 mesh).

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14. The method of claim 12, wherein the first powder is present in an amount from about 15% to about 95% by volume of the powder mixture and the second powder is present in an amount from about 5% to about 85% by volume of the powder mixture.

15. The method of claim 7, wherein the method further comprises:

combining a first powder having a first mesh size, a second powder having a second mesh size, and a third powder having a third mesh size to form a powder mixture, wherein the first mesh size, the second mesh size, and the third mesh size are different and wherein the step of adhering the particles to at least a portion of the sputtering target assembly includes providing the powder mixture to an apparatus for the cold spray or thermal spray technique.

16. The method of claim 7, wherein the particles are adhered to at least a portion of the sputtering target assembly by the cold spray technique.

17. The method of claim 7, wherein the particles are adhered to at least a portion of the sputtering target assembly by the thermal spray technique.

18. The method of claim 17, wherein the thermal spray technique is plasma spray.

19. The method of any of claim 7, wherein prior to adhering the particles to the sputtering target assembly, at least a portion of a surface of the sputtering target assembly is subjected to grit blasting and the particles are adhered to at least a portion of the grit blasted surface.

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